VI. Conventional Systems

Conventional systems cover a broad range of support systems for the operation of the EMC. These systems are:

- low voltage DC power for the front end electronics and associated transmission lines
- Cooling systems for all electronics (i.e., power supplies, crates, FEE, SMD etc.)
- HV for SMD and HV transmission and distribution lines
- Gas system for SMD

A series of general requirements are imposed on all of the above systems by:

- BNL and RHIC safety requirements
- STAR Detector constraints (e.g., integration issues, grounding rules, STAR slow control and monitoring requirement etc.)

In this section we will define only those requirements specific to EMC subsystems.

VI.1.1 Low voltage DC power for FEE

Due to space constraints it is not possible to have self powered crates on the iron backlegs where the FEE crates will be mounted. Therefore, DC power will be supplied from power supplies located in the electronics racks.

Table VI.1 gives the total power requirement for the STAR EMC.

System	power requirement	Total power	Voltages
EMC FEE crates	60 crates@900 watts/crate	54 kW	±5
SMD on board FEE	120 modules @30 watt/mod.	3.6 kW	±5
CW PMT bases	4800 bases @ 0.25 watt/base	1.2 kW	±12
calibration sys.	LED, ^{60}Co source ≈ 1 kW	1 kW	±12
SMD gas system	10 watt@120 mod. (elec. valves)	1.2 kW	+24
cooling system	DC fan trays (estimated)	2.0 kW	+24
misc.	slow control / monitoring system	1.0 kW	±12
reserves	about 20% of total at each voltage	10 kW	±5, ±12

Table VI.1. DC power requirements of various EMC sub-systems.

Power supply outputs shall be regulated over time and temperature, and hardware current limiting will be implemented. Conducted noise due to power supplies will not contribute to the degradation of FEE operation.

The voltages, currents, and temperatures for all DC power supplies shall be monitored, and power supplies shall be remotely controlled via STAR slow controls. All power supplies in the racks shall be cooled using the standard STAR water chilled heat exchanger/fan systems. Due to large currents, voltage losses in the transmission lines are expected to be of the order of 1 volt, therefore all electronics load will have adequate on board filtering and voltage regulation. Furthermore, they will have built in fault protection to protect the circuitry against inductive “kicks”.

VI.1.2 Cooling for the FEE Electronics

Due to the large amount of power dissipation of the FEE it is important to cool these systems. The FEE modules located on the crates installed on the magnet backlegs will be cooled by forced air. The SMD FEE shall be cooled by forced air as well. In order to maintain the gain stability and reduce dark current of the PMTs the temperature in the PMT boxes shall be monitored and a water chilled closed cooling system will be used to maintain the PMT temperature changes to less than 2 degrees C.

All external pipes carrying gas/air to the SMD modules shall be non conductive (i.e. copper pipes will pick up the magnet power supply noise and may couple it to the SMD FEE electronics).

VI.1.3 HV Power for SMD

HV power shall be supplied with low noise power supplies to avoid injection of conducted HF noise into FEE. All supplies shall be remotely controlled via STAR slow controls. Adequate capacitive filtering will be implemented as close to the SMD modules as possible to reduce voltage fluctuations due to transient and avoiding gain fluctuations. The voltages, currents, and temperatures for all HV power supplies shall be monitored, and power supplies shall be remotely controlled via STAR slow controls. The HV transmission lines shall not cause ground loops.

VI.1.4 SMD Gas System

The SMD gas system shall have a two function.

1. it will be used to supply nitrogen gas to 120 SMD modules for flushing the system, and
2. as well as supplying the Ar/CO_2 premixed mixture for normal operation.

The gas system will be un-interruptable, and have enough gas capacity to run for several weeks without the need to replace the gas cylinders. The gas system shall be clean. Oxygen and water vapor impurities shall remain below 100 ppm. The total gas flow rate, and flow through individual SMD modules shall be monitored. The SMD gas system shall not supply a current return path for STAR detector (i.e., main supply line to the Wide Angle hall will stop short of the STAR detector to avoid appreciable capacitive coupling, and the connection to STAR shall be via plastic nonflammable/nonconducting pipes).

VI.2 Discussion of Systems

The Cooling of PMT boxes has been discussed in Chapter V therefore it will not be discussed here.

VI.2.1 Low Voltage DC Power Supplies and Distribution Lines

The choice of having DC supplies at the racks is dictated by: 1) lack of adequate space on the backlegs, 2) the fact that AC power is not available on the detector (to avoid ground loop problems), and 3) the fact that due to presence of magnetic fields it is expected that the magnetic components of AC-DC converters supply may saturate.

Two different schemes have been considered. From an economic point of view it is more attractive to chose a few high-density power supplies (i.e., 10 kW or even higher) to power several crates. While it is functionally better to decouple the power transmission lines to avoid complex, load dependent problems (which could render the system less reliable and unpredictable), it would be possible to carefully design a power grid to avoid most of these problems. In what follows we will describe one scheme, which utilizes individual, isolated power supplies to power each FEE crate. The advantage of this topology is that it is less susceptible to noise.

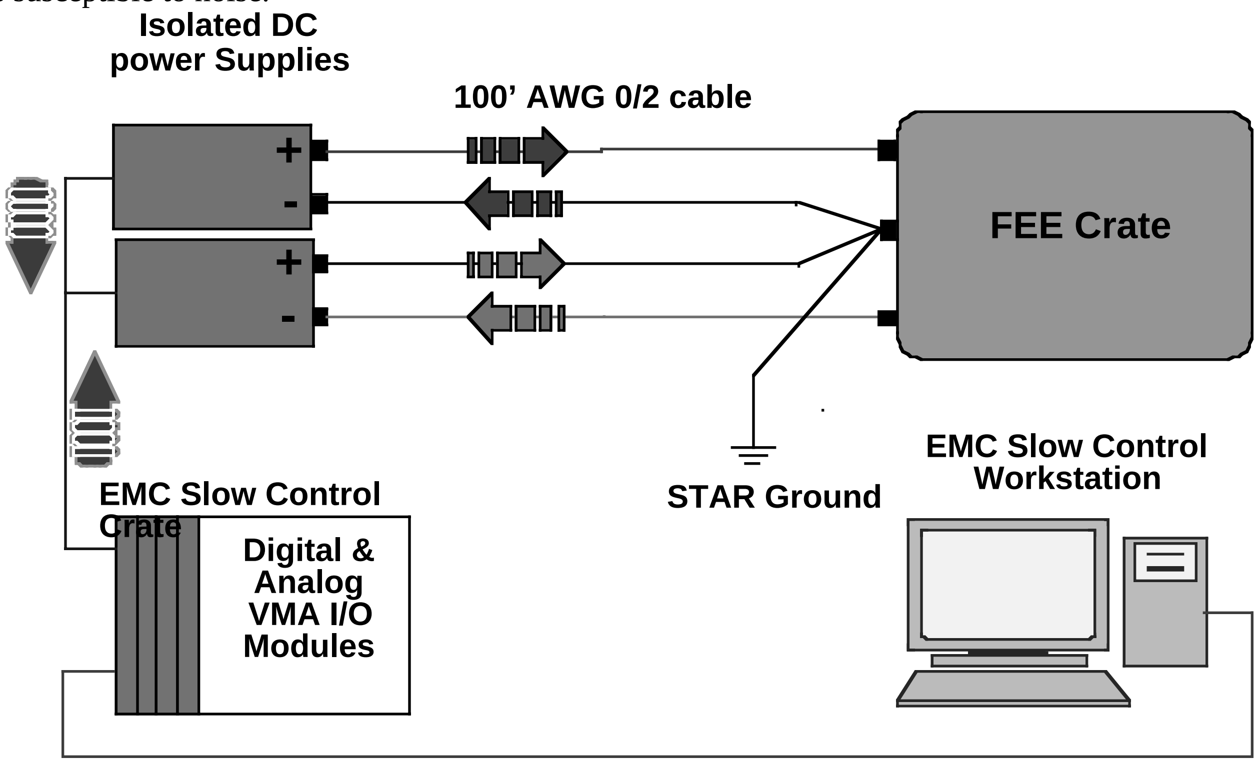

Figure VI.1. A power supply system for FEE crates.

Figure VI.1 shows a conceptual design of a low voltage DC power supply system for the FEE crates. There will be 60 such supply systems arranged in small dedicated crates housed in the EMC racks. Due to the long power transmission lines and large currents involved a large power loss is expected in the transmission lines. For example it is estimated that each FEE crate will dissipate about 900 watts of ±5 DC power. Therefore, the total DC current is 900 watts/5 volts= 180 amps. If we further assume that 125 A of this is in + current, and use AWG 2/0 wire (∅ = 0.3648” resistance/1000’ = 0.08021 @ 20°C)[1] and final operating temperature of 40°C then the resistance for a 100’ cable at 40°C is given by:

$$R(T) = R_{20}(1 + \alpha_{20}(T - 20))$$

For hard drawn copper α_{20}=0.00393/°C, and R_{20} (100’) = 0.008021 Ω, R(40°C) = 0.00865 Ω. This gives a voltage drop of ΔV=1.1 Volts/conductor. Allowing for 2 volt drop for linear[2] regulators at the crates, and 2.2 volt drop in the transmission lines one requires power supply voltage of 9.2 volts.

The power dissipation per conductor will be 135 watts distributed over 100’. The total heat dissipated by DC power transmission conductors for FEE crates 16.2 kW. This will be handled by the

[1] “Reference Data For Engineers: Radio, Electronics, Computer, and Communications”, 8th ed., editor M. E. Van Valkenburg, SAMS, prentice Hall Computer Publishing.

[2] switching regulators are avoided due to possible saturation of their magnetic components in the stray magnetic field.

main air conditioning of the wide angle hall. Assuming 80% efficiency for the power supplies, one obtains heat dissipation of 286 watts/positive DC supply or a total of 17.2 kW.

For the negative DC supply if we chose AWG 2 wire (∅ = 0.2576" resistance/1000' = 0.1625 @ 20°C)[3], one obtains for a 100' cable at 40°C a resistance of 0.0176 Ω. This gives a voltage drop of 1.14 volts. Again allowing for 2 volt drop in the regulators and 2.3 volts in the transmission lines one needs a power supply output of 9.3 volts. The total power dissipation due to -DC power transmission lines is 8.9 kW. The total negative DC power supply dissipation (using the assumptions given for + DC power), is 9 kW.

In addition to the FEE in the crates, the SMD modules will require 30 watts/module in ±5 volts. Due to the large number of SMD modules it is more prudent to use single power supply to power multiple modules. A SMD conventional system distribution box will handle filtering/regulation of DC power on the iron backleg, and transmission of regulated power to the module. The details of this are being worked out at this time.

The power for the CW bases will be derived from ±12 volt DC supplies. The total power is estimated to be 1.2 kW for 4800 PMTs or 4.8 kW if a zener is to be employed between the photocathode and the first dynode stages. If we take the 4800 as an upper limit this gives 80 watts per PMT box (i.e., 60 PMT bases/box). This is equivalent to 6.7 A that will be bussed inside the PMT boxes. The details of power buss and its integration are being designed. The heat deposited by the PMT bases as well as the LED drivers and the cooling fans located inside the boxes will be removed by a water-chilled heat exchanger. This was discussed to some extent in section V.4. Further work on the integration issues on this matter is pending.

VI.2.2 Cooling for FEE Electronics

The FEE electronics housed in the crates on the backlegs will be cooled with fan trays. This is a fairly large heat load that ordinarily will have to be handled by dedicated closed system water chilled heat exchangers. However, due to lack of space this can not be done. Therefore the heat load will have to be handled by the WAH A/C system.

The SMD electronics will be located inside the STAR magnet. In order to cool it pressurized air will be pumped into the SMD electronics air-cooled heat exchangers via plastic hoses. The hot air will be removed via outlet hoses and vented into the WAH.

VI.2.3 HV Power for SMD

The HV for SMD modules will be supplied with 6 low noise BERTAN power supplies. These power supplies will be mounted in the EMC racks, and will controlled and monitored via EMC slow controls. Filtering and distribution of the HV to various module will be done by 60 (2 per backleg each located on the end of the detector) SMD conventional systems boxes installed on the iron backleg. Some details of the design of these "Utility" boxes will be discussed in the next section.

VI.2.3 The SMD Gas System

Some details of gas system and the required gasses and their flow rates have been given in the previous chapters. In this section we will only present some details of the gas manifold, and the distribution system.

[3] "Reference Data For Engineers: Radio, Electronics, Computer, and Communications", 8th ed., editor M. E. Van Valkenburg, SAMS, prentice Hall Computer Publishing.

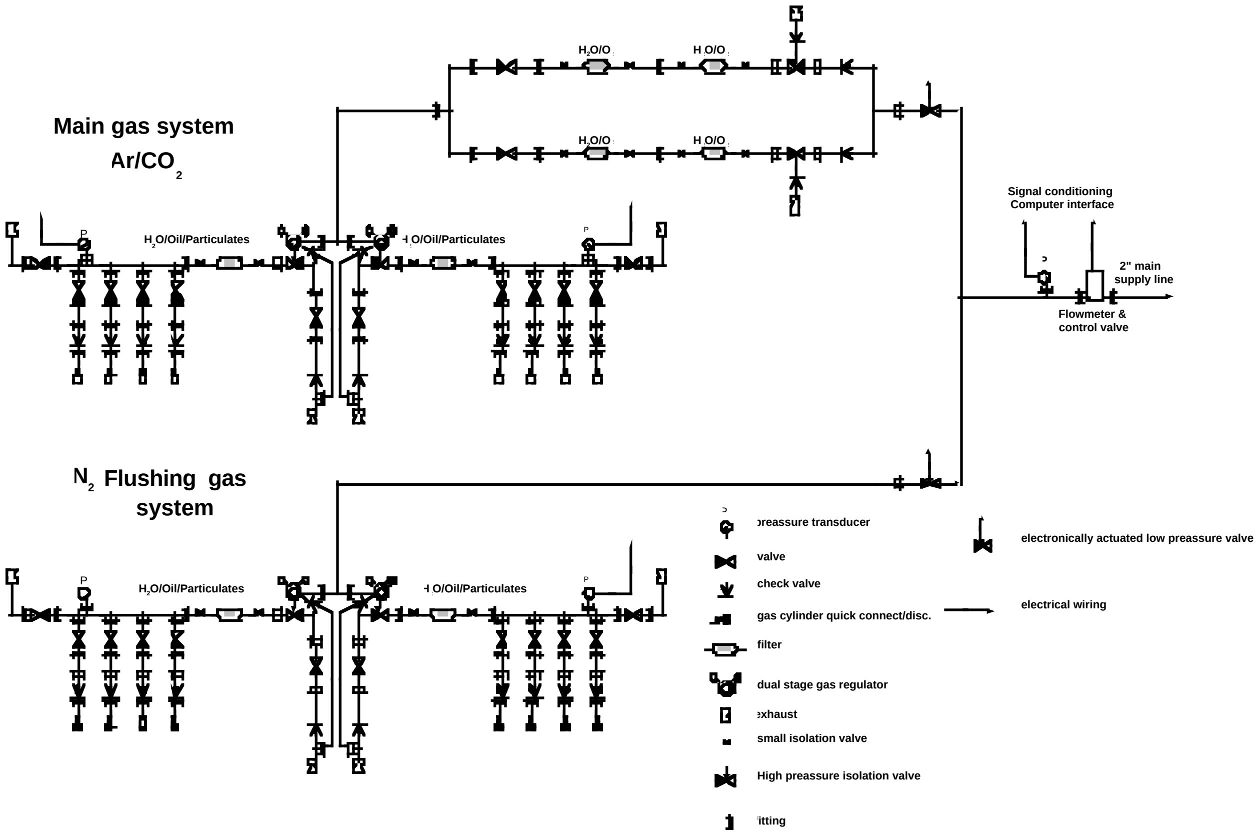

Figure VI.2. The gas supply manifold.

The SMD gas system may be broken down into three parts:

- The gas supply manifold
- The gas distribution system
- The slow control system to control and monitor the gas system.

Figure VI.2 is schematic of a preliminary design for the gas supply manifold. As seen in this figure the manifold consists of two independent gas systems, namely a premixed Ar/CO_2 un-interruptable manifold and a N_2 flushing gas manifold. Only one of these gas manifolds may be connected to the main supply line at a given time. The rough filtering section is designed to remove oil and dust particles while a second level of filtering will remove the remaining water vapor and oxygen gasses. The pressure and flow rates will be monitored and controlled at all times. Both the gas supply section and the filtering section are designed such that one may replace cylinders and filters without interrupting the main gas flow, or injecting impurities into the main system.

The gas will be supplied to the detector via a 2” copper pipe. This line will be split into two 1” high-pressure plastic hoses that will distribute the gas to each end of the magnet. At that point each 1” diameter pipe will be connected to the inlet port of one of the SMD “utility” boxes. Each “utility” box consists of an inlet and outlet. These boxes will be daisy chained by connecting the outlet port of one box to the inlet of the next via flexible plastic tubing. The pressure drop between the first box and the last will be less a fraction of psi due to low flow rates in the SMD. The advantage of this system is its flexibility and expandability. Internally each box has several functions. As mentioned earlier it will be used to distribute LV, HV, pressurized cooling air for SMD FEE cooling and finally the distribution of the gas to the SMD and monitoring of flow rate out of the modules. Figure VI.3 shows some of the details of the utility box and its “daisy chained” arrangement at one end of STAR magnet iron backlegs.

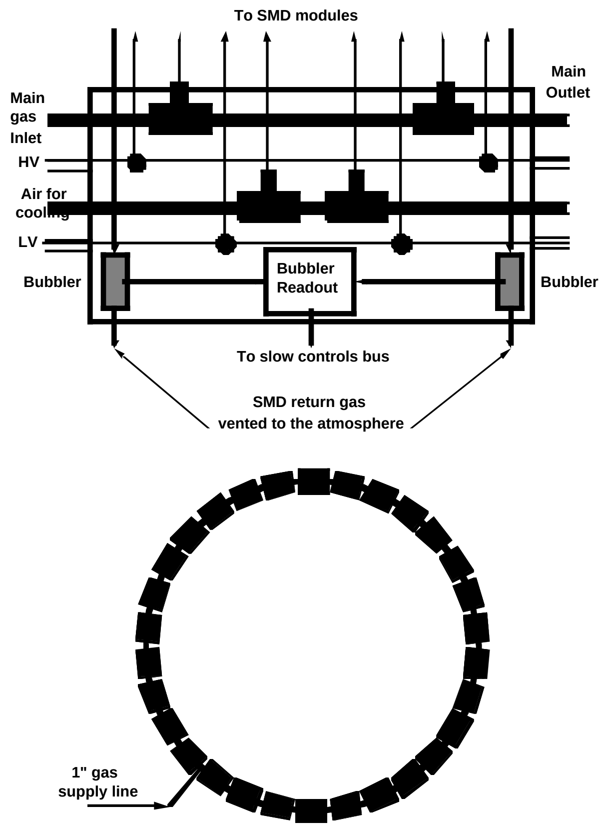

Figure VI.3. Top: conceptual design of the SMD utility box, Bottom: arrangement of 30 utility boxes at one end of the detector.

The third major part of the SMD gas system is the slow control and monitoring of the system. As mentioned earlier the gas pressure, and flow rate will be monitored for the main supply line. In addition as seen in figure VI.3, the outlet gas from each module will be channeled through a bubbler where, by use of a photocell, the bubbling rate will be monitored via the slow control bus.

In order to operate the system in flushing mode (i.e., use nitrogen to flush air and water vapor from the SMD), one will need to use higher flow rates. This may be accomplished by either: 1) keeping the “utility” box outlet (to SMD) orifice the same and increase the gas pressure, or 2) use an electrically controlled solenoid valve with two outlets with two different orifices to switch from higher flow rates to lower ones.